<u>DRAFT</u> Total Maximum Daily Load (TMDL) Study for Bacteria in Sand Dam Village Pond Town Beach, Troy, New Hampshire

Prepared by:

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August 2006

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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DRAFT Total Maximum Daily Load (TMDL) Study for Bacteria in Sand Dam Village Pond Town Beach Troy, New Hampshire

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1 INTRODUCTION

1.1 Background

Section 303(d) of the Clean Water Act ("CWA") and the federal Water Quality Planning Regulations (40 CFR Part 130) require States to prepare a list (commonly called the 303(d) List) of all waters that are threatened or impaired by pollutants and are not expected to meet water quality standards even after implementation of technology-based controls for pollution such as secondary treatment for municipal wastewater treatment facilities. The 303(d) List is updated and issued for public comment every two years. The public comment period usually occurs in February or March of even numbered years with the final list submitted by April 1st to the United States Environmental Protection Agency (EPA) for approval. The most recent 303(d) list was submitted to EPA on March 31, 2006.

For all waters on the 303(d) List, Section 303(d) of the CWA also requires States to establish Total Maximum Daily Loads ("TMDLs") for the pollutants causing the impaired or threatened status. The total maximum daily load is the maximum daily load the waterbody can assimilate and still meet water quality standards. Water quality standards include numeric and narrative criteria that must be met to protect the uses of the surface water such as swimming, boating, aquatic life, and fish consumption. TMDL studies estimate required pollutant load reductions and map a course for stakeholders to follow that should lead to restoration of the impaired water and its uses. In general, the steps involved in the TMDL process include the following:

- Identification of the major sources of pollutant(s);
- Estimation of existing pollutant loadings from each major source;
- Calculation of the maximum load (ie. the TMDL) that the surface water can assimilate and still meet water quality standards;
- Allocation of the maximum load among point and nonpoint sources;
- Calculation of the reduction in pollutant load needed to achieve water quality standards;
- Recommendations for implementing the TMDL so that water quality standards will ultimately be achieved;
- Opportunity for public comment prior to finalizing the TMDL;
- Submission of the final TMDL by the State to the U.S. Environmental Protection Agency ("EPA") for final approval.

1.2 Problem Statement and Purpose of Study

Sand Dam Village Town Beach (the "Beach") is a designated beach located in the town of Troy on the northeast corner of Sand Dam Village Pond just upstream of the dam (see Figure 1). According to New Hampshire's methodology for assessing the quality of

surface waters (NHDES, 2005b), a designated beach is an area on a waterbody that is operated for bathing, swimming, or other primary water contact by any municipality, governmental subdivision, public or private corporation, partnership, association or educational institution, open to the public, members, guests, or students whether on a fee or free basis. Under RSA 485-A:8.I , "…designated beach areas shall contain not more than a geometric mean based on at least 3 samples obtained over a 60-day period of 47 Escherichia coli per 100 milliliters, or 88 Escherichia coli per 100 milliliters in any one sample; unless naturally occurring."

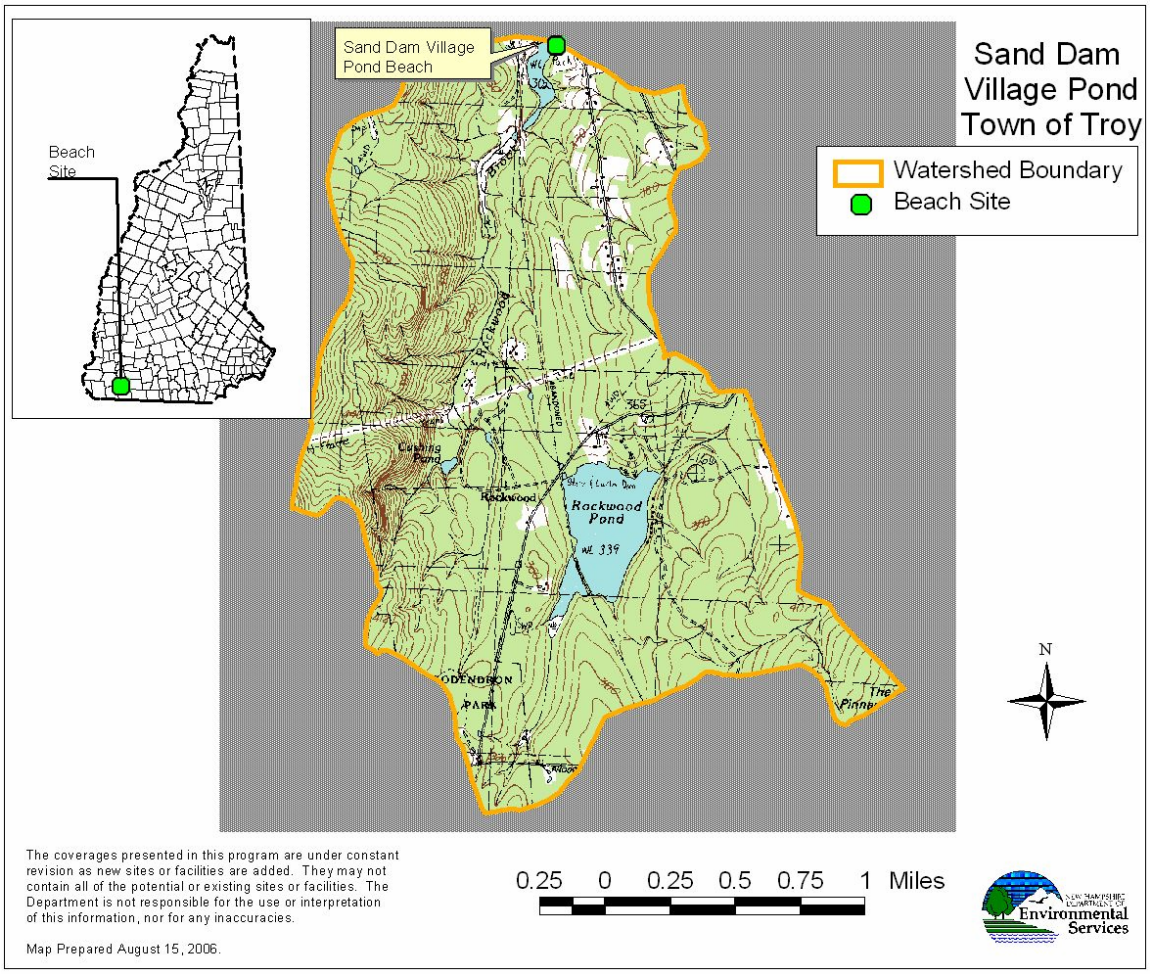
To facilitate tracking and assessing surface water quality, all surface waters in New Hampshire are assigned a unique identification number (called an Assessment Unit or AU number). The AU number assigned to the Beach swimming area is NHIMP802010303-04-02. This AU is currently listed as impaired on the 2006 303(d) list for primary contact recreation (i.e., swimming) due to violations of surface water quality standards for bacteria (*Escherichia coli* or *E. coli* for short). Waters with elevated bacteria levels can result in swimmer's itch and gastrointestinal illnesses if ingested. As such the Beach has been posted by the New Hampshire Department of Environmental Services ("NHDES") on several occasions in the past as being potentially unfit for swimming.

The purpose of this study is to:

1. Determine the primary sources of *E. coli* to the Beach;
2. Determine the TMDL for *E. coli* that will achieve water quality standards;
3. Allocate the TMDL between point and nonpoint sources;
4. Determine reductions in *E. coli* needed achieve the TMDL;
5. Provide a plan to guide implementation of the TMDL in a phased approach that will ultimately result in attainment of water quality standards and a beach with bacteria levels acceptable for swimming.

Although bacteria is the focus of this study it is worth mentioning that all surface waters in New Hampshire (including the Beach), as well as in some New England States, are also listed as impaired for fish consumption due to mercury concentrations in fish tissue. Because of the levels of mercury found in fish tissue throughout New Hampshire's surface waters, a state-wide advisory was issued in the mid-1990's limiting the amount of fish one should eat. The sources of the mercury contamination in fish tissue are thought to be more regional (e.g., atmospheric deposition from upwind states) than local. In the future it is expected that a separate TMDL will be developed to address impairments due to mercury in all surface waters.

Figure 1: Locus Plan and Watershed for Sand Dam Village Pond



2 APPLICABLE WATER QUALITY STANDARDS AND TARGETS

2.1 Overview

Water Quality Standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts; classification, criteria, and antidegradation regulations, each of which are described below.

Classification of surface waters is accomplished by state legislation under the authority of RSA 485-A:9 and RSA 485-A:10. By definition, (RSA 485-A:2, XIV), "surface waters of the state means streams, lakes, ponds, and tidal waters within the jurisdiction of the state, including all streams, lakes, or ponds, bordering on the state, marshes, water courses and other bodies of water, natural or artificial."

All State surface waters are either classified as Class A or Class B, with the majority of waters being Class B. DES maintains a list which includes a narrative description of all the legislative classified waters. Designated uses for each classification may be found in State statute RSA 485-A:8 and are summarized below.

Classification	Designated Uses
Class A -	These are generally of the highest quality and are considered potentially usable for water supply after adequate treatment. Discharge of sewage or wastes is prohibited to waters of this classification.
Class B -	Of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for use as water supplies.

According to New Hampshire's assessment and listing methodology (NHDES, 2005) designated uses for New Hampshire surface waters include those shown in the following table.

Table 1: Designated Uses for New Hampshire Surface Waters

Designated Use	DES Definition	Applicability
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply	Waters that with conventional treatment will be suitable for human intake and meet state/federal drinking water regulations.	All fresh surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

The second major component of the water quality standard is the "criteria." These are numeric or narrative criteria which define the water quality requirements for Class A or Class B waters. Criteria assigned to each classification are designed to protect the legislative designated uses for each classification. A waterbody that meets the criteria for it's assigned classification is considered to meet it's intended use. Water quality criteria for each classification may be found in RSA 485-A:8, I-V and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700). A copy of Env-Ws 1700 is available at http://www.des.state.nh.us/rules/env-ws1700.pdf.

The third component of water quality standards are antidegradation provisions which are designed to preserve and protect the existing beneficial uses of the State's surface waters and to limit the degradation allowed in receiving waters. Antidegradation regulations are included in Part Env-Ws 1708 of the New Hampshire Surface Water Quality Regulations. According to Env-Ws 1708.02, antidegradation applies to the following:

- All new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect the existing or designated uses.
- A proposed increase in loadings to a waterbody when the proposal is associated with existing activities.
- An increase in flow alteration over an existing alteration.
- All hydrologic modifications, such as dam construction and water withdrawals.

2.2 Applicable Water Quality Standards

As mentioned in section 1.2, Sand Dam Village Pond Town Beach is a designated beach. There are two designated uses for designated beaches that are relevant to bacteria pollution: primary contact recreation (e.g., swimming) and secondary contact recreation (e.g., boating). The Sand Dam Village Pond Town Beach assessment unit is listed as impaired for primary contact recreation (i.e., swimming) due to violations of state water quality criteria for bacteria (*E. coli*). The Beach is a Class B surface water and the applicable water quality standards for the designated uses are provided below.

> State Statute RSA 485-A:8,II: Designated beaches in Class B surface waters "shall contain not more than a geometric mean based on at least 3 samples obtained over a 60 day period of 47 *Escherichia coli* per 100 milliliters, or 88 *Escherichia coli* in any one sample; unless naturally occurring".

Though not currently listed as impaired for bacteria due to a lack of data, the remaining portion of Sand Dam Village Pond which is not a designated beach, is also a Class B surface water. Applicable bacteria water quality standards for protecting primary contact recreation uses in such waters are less stringent than for designated beaches and are provided below:

> State Statute RSA 485-A:8,II: Class B surface waters that are not designated beaches "shall contain not more than either a geometric mean based on at least 3 samples obtained over a 60 day period of 126 *Escherichia coli* per 100 milliliters, or greater than 406 *Escherichia coli* in any one sample" unless naturally occurring.

In addition, the 2006 assessment and listing methodology (NHDES, 2005b) includes bacteria standards to protect secondary contact recreation (i.e., boating). These standards are five times higher than the bacteria criteria shown above for primary contact recreation.

The bacteria standards discussed above apply in the surface water. As indicated below, however, New Hampshire surface water quality regulations also specify that ambient bacteria criterion must also be met at the end of discharge pipe(s) from wastewater treatment facilities [Env-Ws 1703.06(b)]. Further, Env-Ws 1703.06 (c) requires that the bacteria concentration in the discharge pipe(s) from combined sewer

overflows (i..e., pipes that convey a mixture of stormwater and untreated sewage during wet weather events), must not exceed 1000 *Escherichia coli* per 100 mL.

Env-Ws 1703.06 Bacteria

(b) Subject to (c) below, the bacteria criteria shall be applied at the end of a wastewater treatment facility's discharge pipe.

(c) For combined sewer overflows which discharge into non-tidal waters, a bacteria criteria of 1000 Escherichia coli per 100 milliliters shall be applied at the end of the combined sewer overflow's discharge pipe.

2.3 Targeted Water Quality Goals

The targeted water quality goal for this TMDL is for the bacteria concentrations in the Sand Dam Village Pond Town Beach assessment unit to meet all the water quality standards for all the designated uses affected by bacteria pollution; that is, primary and secondary contact recreation. Of these two designated uses, the water quality standards for primary contact recreation are the most stringent. Therefore, the targeted goal for this TMDL is for the water quality at Sand Dam Village Pond Town Beach to meet both aspects of the NHDES primary contact recreation bacteria water quality standard (geometric mean of 47 and single sample of 88 *E. coli* / 100 mL). The bacteria reductions needed to meet the primary contact recreation standard for designated beaches will ensure secondary contact recreation standards will be met.

These reductions should also help ensure that bacteria standards in the main part of Sand Dam Village Pond are met due to the relatively small size of the pond, its proximity to the Beach and the fact that the bacteria standards for non-designated beach portion of the pond are less stringent than for the Beach. Consequently, measures taken to achieve bacteria standards at the Beach should result in standards being met in the non-designated beach portion of Sand Dam Village Pond as well.

3 BEACH WATER QUALITY CHARACTERIZATION

3.1 Watershed / Waterbody Description

The Sand Dam Village Pond Town Beach swimming area (the "Beach") is located in Troy, New Hampshire in the upper portion of the South Branch Ashuelot River watershed (see Figure 2). The Beach is located in the northeast corner of Sand Dam Village Pond just east of the dam (see Figures 2 and 3). Rockwood Brook, which is a tributary to the South Branch Ashuelot River, flows through Sand Dam Village Pond.

The drainage area of Sand Dam Village Pond is approximately 2,456 acres in size and includes the headwaters of Rockwood Brook as well as Rockwood Pond which is located approximately 1.5 miles upstream of Sand Dam Village Pond (see Figure 2) The watershed is primarily forested with some residential land use and open land (i.e., ball fields) located in the vicinity of the pond (see Figure 2 and 3).

Figure 2: Aerial Photo of Sand Dam Village Pond Watershed

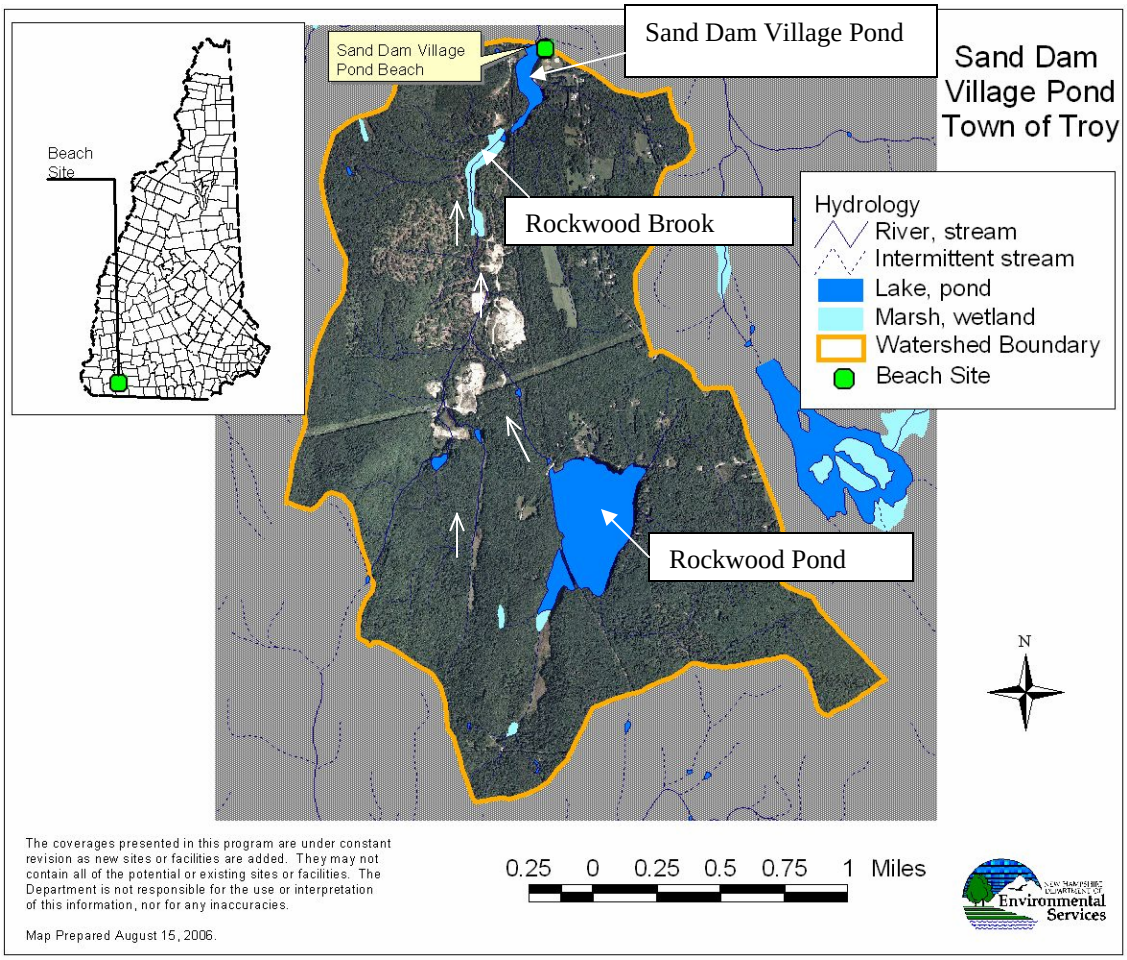
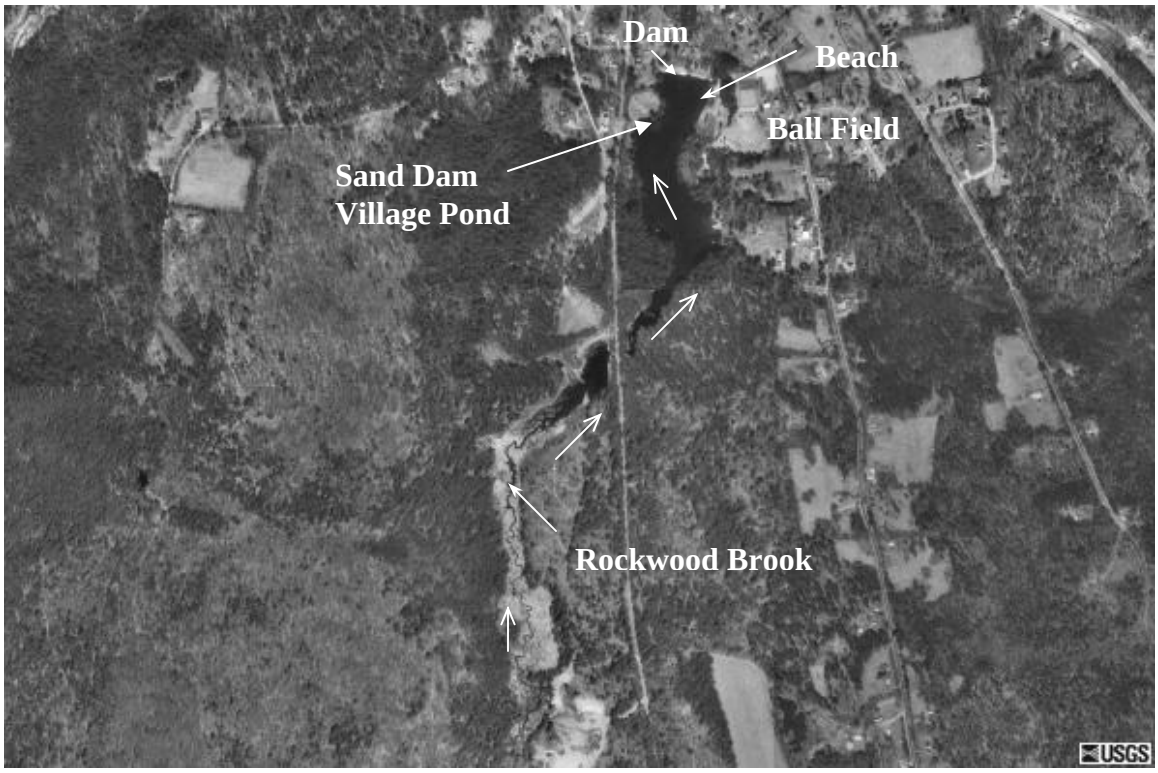


Figure 3: Aerial Photo Showing Land Use Just Upstream of Beach



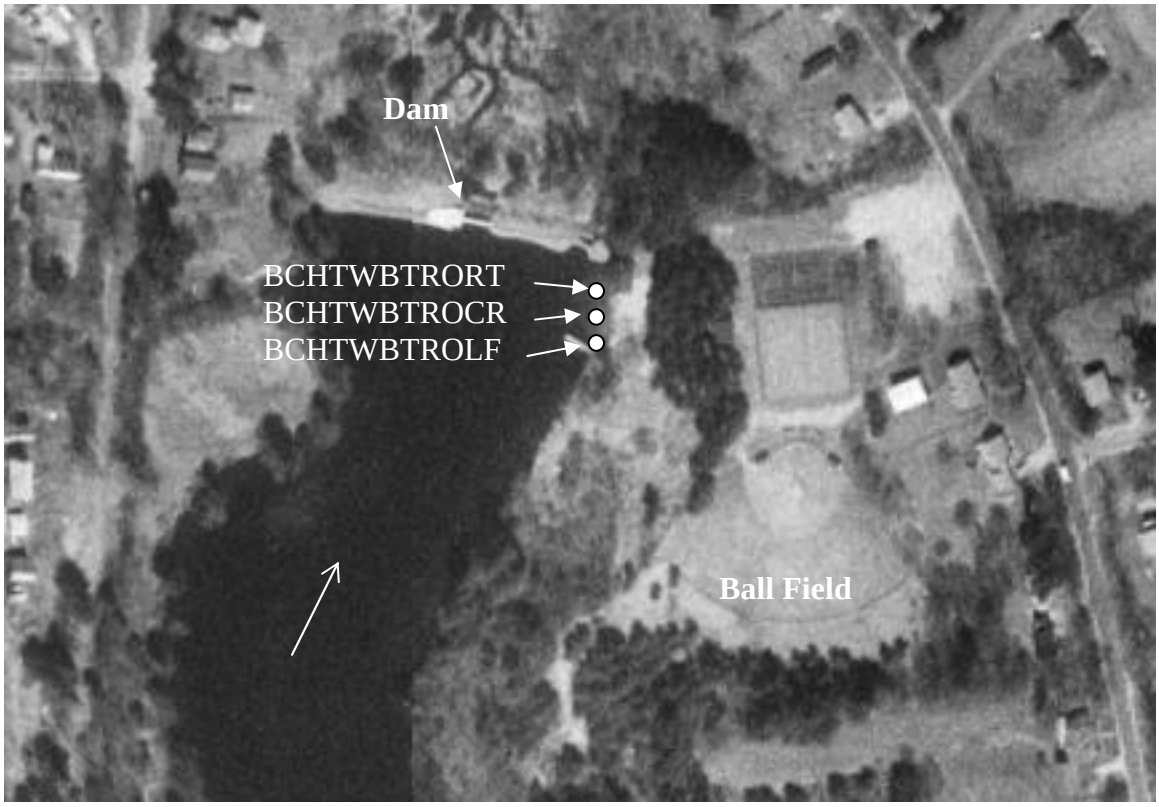
The Sand Dam Village Town Beach swimming area is approximately 70 feet long with an average water width of approximately 50 feet from the shoreline to the swim rope. The average water depth of the beach swimming area is estimated to be two feet. Therefore, the total surface area of the beach swimming area is approximately 3,500 ft^2 with a water volume of approximately 7,000 ft^3.

3.2 Bacteria Sampling for Compliance with Water Quality Standards

Data from the NHDES Public Beach Inspection Program was used to characterize the baseline concentration of bacteria in Sand Dam Village Pond Town Beach and for determining compliance with water quality standards. From 1991 – 2004 the beach was sampled one to four times per year. In 2005, more intensive monitoring was conducted in support of the TMDL.

There are three designated beach monitoring stations at the Sand Dam Village Pond Town Beach swimming area (see Figure 4). Looking out from the beach to the pond, Station BCHTWBTROLF is located on the left side, station BCHTWBTROCR is in the center, and station BCHTWBTRORT is on the right side of the beach swimming area.

Figure 4: Aerial Photo of Beach with 2005 Sampling Stations



The NHDES Public Beach Inspection Program monitored these stations in response to the potential health threats associated with water-borne pathogens. Samples are collected during the months of June through August to correspond with the season when bathers are most likely to use the beach.

In 2005 the NHDES Public Beach Inspection Program implemented a more detailed sampling plan at Sand Dam Village Pond Town Beach to collect data in support of developing a TMDL. Prior data indicated that this beach has experienced chronic bacteria exceedances during the summer swimming months. These exceedances have resulted in the need for bacteria advisories.

To calculate the water quality statistics for the receiving waters all of the *E.coli* measurements were compiled from the three stations at Sand Dam Village Pond Town Beach from 1991 to 2005. All data used for these calculations passed the quality assurance protocols of the NHDES Public Beach Inspection Program. The data collected in 2005 also passed the quality assurance protocols detailed in the Quality Assurance Project Plan prepared for this study, a copy of which is included in Appendix A.

Before discussing results it is useful to first review how multiple samples taken on a given day are assessed to determine if a waterbody is impaired or attaining standards.

The two components of the water quality standard for *E. coli* in freshwater beaches are the geometric mean ("geomean") and single sample measurements. On any given sampling day either two or three of the stations were sampled (e.g., the left, center and/or right side of the beach swimming area). In terms of determining compliance with water quality standards the maximum value of the samples collected on a given day are used. Thus the statistic "daily maximum" is used for purposes of water quality standards.

The geomean is calculated for a minimum of three samples collected within a sixty day period using the following formula:

$$\text{Geometric Mean} = (D1 \times D2 \times \ldots Dn)^{1/n}$$

where

D1, D2, etc. = the individual data points
n = the total number of data points used in the calculation.

As mentioned in section 2.2, the water quality standards for primary contact recreation in fresh water designated beaches are based on *E. coli* concentrations. The geometric mean criterion is 47 cts/100mL based on at least three samples over a sixty day period, and the maximum single sample criterion is 88 cts/100mL.

Table 2, Figure 5 and Figure 6, summarize the single sample daily maximum and geometric mean bacteria concentrations using all of the data collected by the Public Beach Inspection Program from 1991 through 2004. Of the data useable for assessment purposes during this time period, there were thirteen violations of the single sample maximum criterion and five violations of the geometric mean criterion.

Table 2: Sand Dam Village Pond Town Beach Bacteria Results 1991 – 2004

DATE	DES PUBLIC BEACH INSPECTION PROGRAM MONITORING STATIONS			STATISTICS FOR ASSESSMENTS	
	BCHTWBTROLF SINGLE SAMPLE	BCHTWBTROCR SINGLE SAMPLE	BCHTWBTRORT SINGLE SAMPLE	SINGLE SAMPLE DAILY MAX	GEOMETRIC MEAN
7/16/91	93	130	200	**200***	
7/23/92	4		3	4	
6/22/93	10		12	12	
7/6/93	8		11	11	
6/21/94	80		66	80	
6/27/94	17		28	28	
7/11/95	12		10	12	
7/24/96	0		0	0	
7/15/97	17		6	17	

7/10/98	4		10	10	
8/12/98	12		15	15	
7/22/99	30		27	30	
7/18/00	200		200	**200**	
7/27/00	66	200	200	**200**	
7/30/00	16	10	12	16	**86**
7/19/01	7		9	9	
8/16/01	10		10	10	
7/18/02	10		7	10	
8/30/02	131		112	**131**	
6/25/03	2		3	3	
7/31/03	58		170	**170**	
8/7/03	96		170	**170**	
8/22/03	4		12	12	32
7/20/04	14		38	38	
8/10/04	320		200	**320**	

Escherichia coli units in CTS/100 ml
Highlighted cells are >88 for daily maximums and > 47 for geometric means
* Value reported as >200 cts/100ml

Figure 5: Single Sample E. coli Results at the Beach 1991-2004

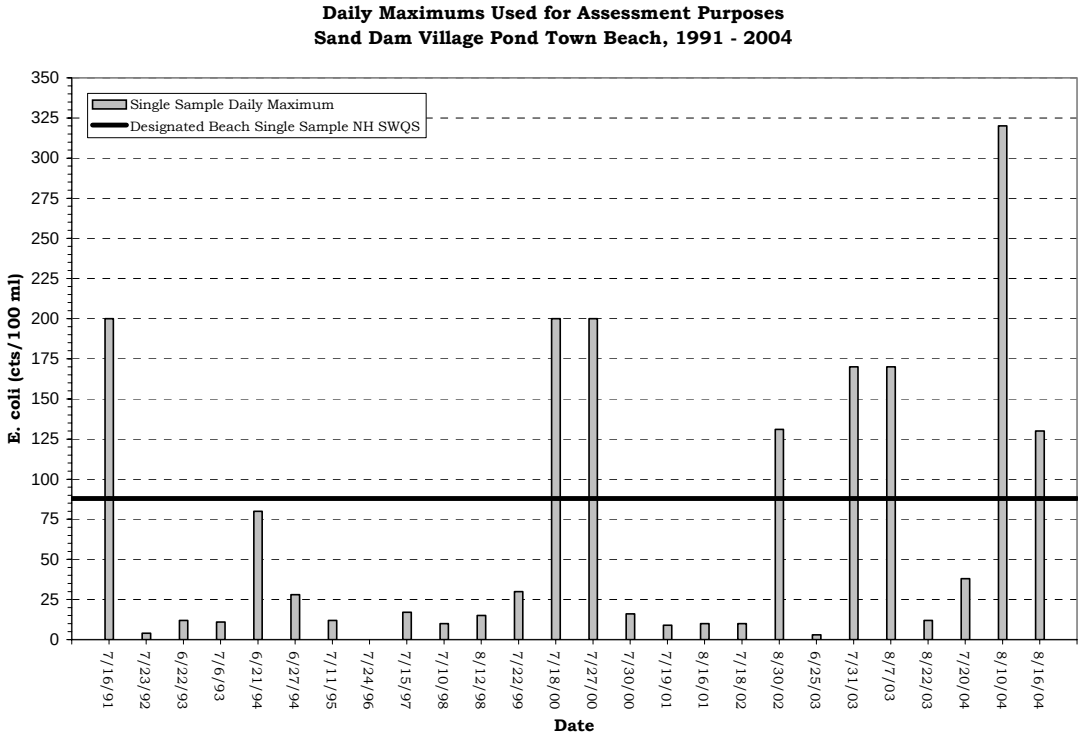
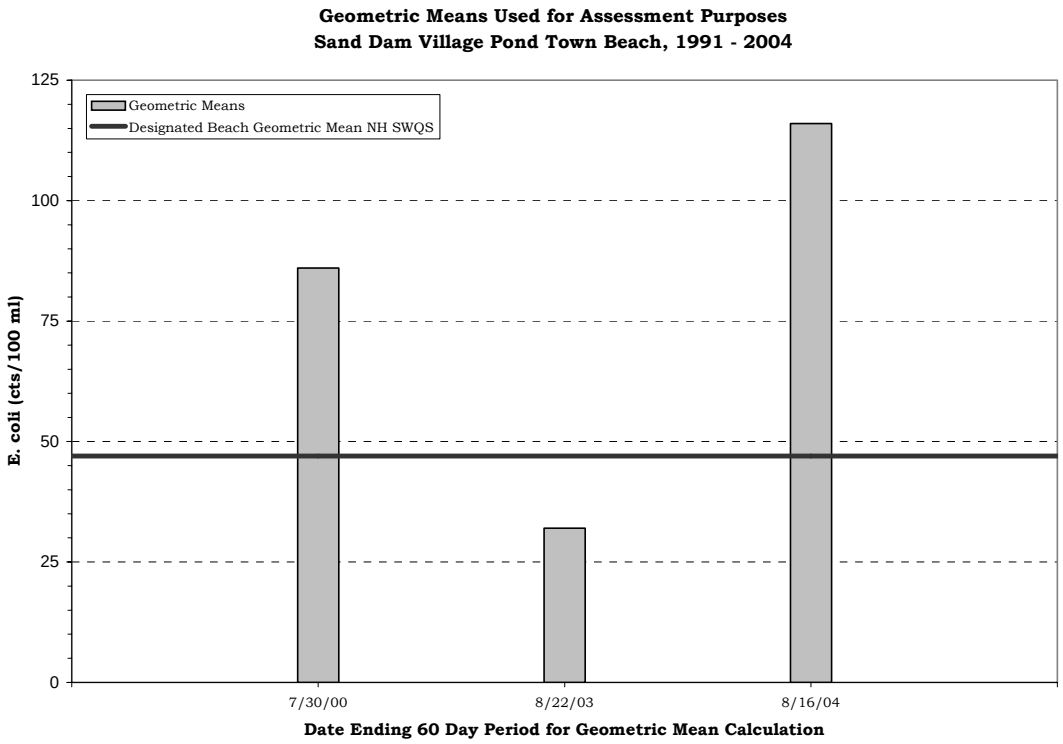


Figure 6: Geometric Mean E. coli Results at the Beach 1991 – 2004



During 2005, the Public Beach Inspection Program conducted a more intensive sampling program at Sand Dam Village Pond Town Beach to assist in the development of this TMDL. Table 3 depicts the single samples, daily maximums, and geometric mean results generated from the data collected in 2005. Figure 7 depicts the single sample daily maximums and Figure 8 shows the geometric mean values.

Table 3: 2005 Single Sample, Daily Maximum and Geometric Mean E. coli Results

DATE	DES PUBLIC BEACH INSPECTION PROGRAM MONITORING STATIONS			STATISTICS FOR ASSESSMENTS	
	BCHTWBTROLF SINGLE SAMPLE	BCHTWBTROCR SINGLE SAMPLE	BCHTWBTRORT SINGLE SAMPLE	SINGLE SAMPLE DAILY MAX	GEOMETRIC MEAN
5/26/05	2	2	8	8	
6/14/05	10	12	40	40	
6/22/05	6	62	18	62	
6/29/05	314	400	400	**400***	
7/1/05	398	380	362	**398**	
7/5/05	28	68		68	
7/12/05	6		46	46	
7/15/05	400	400	400	**400**	
7/18/05	190	400	400	**400**	
7/19/05	100		70	**100**	
7/21/05	100	150	212	**212**	**112**
7/26/05	16	400	400	**400***	
8/3/05	16	18	230	**230**	
8/11/05	6	80	120	**120**	**160**
8/18/05	354	190	70	**354**	**190**
8/23/05	4	400	278	**400***	**219**
8/30/05	54	96		**96**	**196**

Escherichia coli units in CTS/100 ml
Highlighted cells are >88 for daily maximums and > 47 for geometric means
* Value reported as >400 cts/100ml

Figure 7: Single Sample E. coli Results Sand Dam Village Pond Town Beach 2005

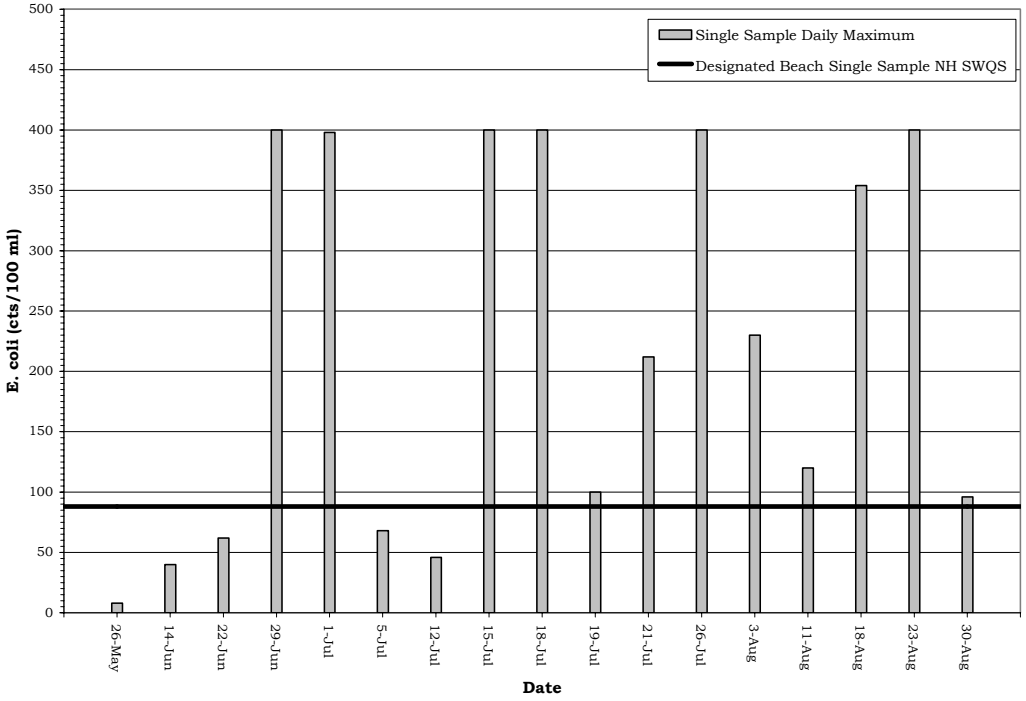
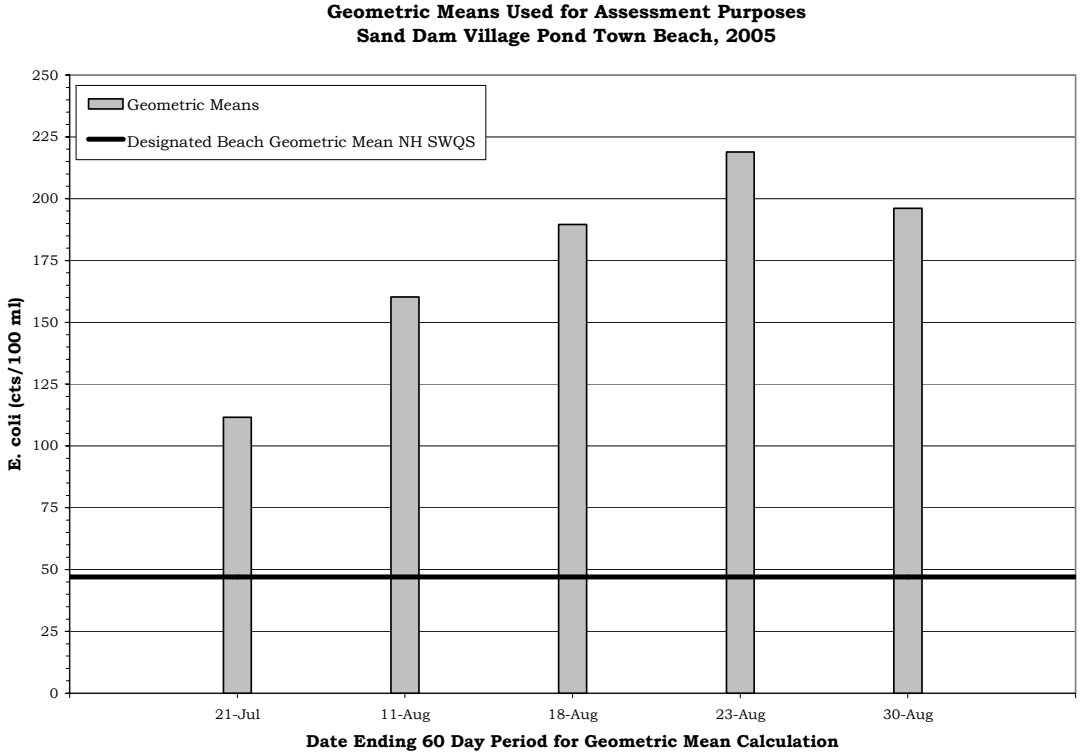


Figure 8: Geometric Mean E. coli Results Sand Dam Village Pond Town Beach 2005



The results of *E.coli* monitoring at Sand Dam Village Pond Town Beach presented above show that the bacteria levels at the Beach violate the bacteria criteria established for primary contact recreation on numerous occasions. Consequently, in accordance with the New Hampshire's assessment and listing methodology (NHDES, 2005), Sand Dam Village Pond Beach was listed as impaired for primary contact recreation on the 2006 303(d) List of impaired or threatened waters that require a TMDL.

To gain an understanding of how bacteria levels may vary with precipitation, the 2005 single sample results were compared to field observations at the Beach and precipitation data recorded at the National Weather Service station located at Keene airport (see Table 4). A wet event was defined as 0.25 inches or more of rainfall in the past 24 hours. Based on this definition, and as shown in Table 4, 12 of the 2005 sampling dates were dry and five were wet. Eight of the 12 dry samples, and four of the five wet samples violated the single sample criterion of 88 cts/ 100 ml.

Figure 9 shows a plot of E. coli concentration for the wet and dry samples. As shown, E. coli concentrations vary greatly under both wet and dry conditions with some samples being above and some below the criterion although the average wet weather concentration was slightly higher than the dry weather (261 vs 202 cts / 100 ml). This suggests that in order to restore water quality in the Beach swimming area, it will be necessary to focus on both dry and wet weather sources of bacteria.

Although violations occur during dry weather, Figure 10 shows that when precipitation exceeds approximately 0.25 inches of rain within the previous 24 hours, bacteria concentrations almost always exceed the single sample criterion of 88 cts/ 100 ml. Consequently, as a minimum, it is recommended that the Beach be closed when rainfall exceeds 0.25 inches. For more discussion regarding beach closures based on rainfall amounts, see section 6.1.

Table 4: 2005 Single Sample E. coli and Precipitation Data

	E coli (cts/100 ml)				Keene National Weather Service Daily Rainfall Data			Beach Sampling Field Notes	Wet or Dry
Date	LF	CR	RT	MAX	Rain Day of	Rain 1 Day Prior	1 Day Prior + Day of		
26-May	2	2	8	**8**	1.41	0.13	1.54	OVER 2 INCHES OF RAIN PRIOR 3 DAYS	**Wet**
14-Jun	10	12	40	40	0.19	0.00	0.19	6/13/05 PM RAIN AND T STORMS	Dry
22-Jun	6	62	18	62	0	0.00	0	RAINED LAST NIGHT.	Dry
29-Jun	314	400	400	**400**	0.24	0.79	1.03	HEAVY RAINS LAST NIGHT.	**Wet**
1-Jul	398	380	362	**398**	1.21	0.58	1.79		**Wet**
5-Jul	28	68	tntc	68	0	0.00	0		Dry
12-Jul	6		46	46	0	0.00	0		Dry
15-Jul	400	400	400	**400**	0	0.52	0.52	HEAVY RAINS LAST NIGHT.	**Wet**
18-Jul	190	400	400	400	0.07	0.02	0.09	RAINED LAST NIGHT OR EARLY AM	Dry
19-Jul	100		70	**100**	0.95	0.07	1.02		**Wet**
21-Jul	100	150	212	212	0	0.01	0.01		Dry
26-Jul	16	400	400	400	0	0.00	0		Dry
3-Aug	16	18	230	230	0	0.00	0	RAINED MONDAY NIGHT.	Dry
11-Aug	6	80	120	120	0	0.00	0		Dry
18-Aug	354	190	70	354	0	0.00	0		Dry
23-Aug	4	400	278	400	0	0.00	0		Dry
30-Aug	54	96	52	96	0.12	0.01	0.13	CURRENTLY RAINING	Dry

Note: the highlighted value of 0.79 in the table was reported in Keene data set as 7.9 which believed to be a data reporting error.

Figure 9: 2005 Maximum Single Sample E. coli vs Precipitation (Wet or Dry)

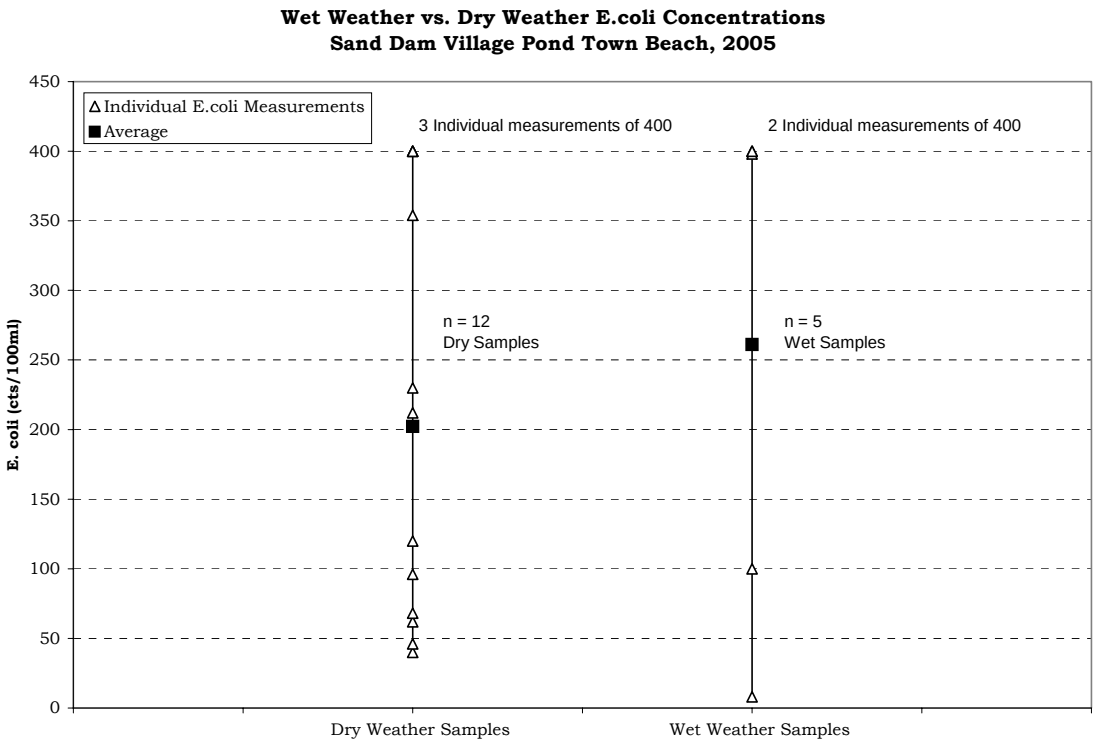
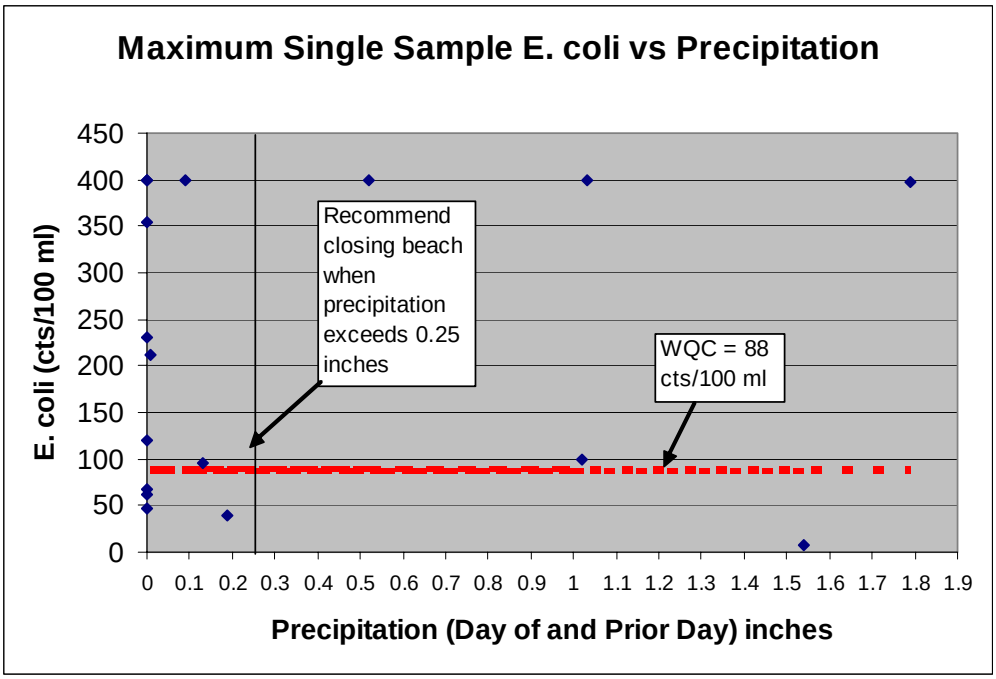


Figure 10: 2005 Maximum Single Sample E. coli vs Precipitation (inches)



3.3 Microbial Source Tracking (i.e., Ribotyping) Results

To help determine the sources of bacteria to Sand Dam Village Pond Town Beach a microbial source tracking technique called "ribotyping" was conducted by the University of New Hampshire during the summer of 2005 (Jones 2006). Ribotyping is an analytical technique used to determine the source(s) of bacteria in a sample (i.e., human, waterfowl, pets, etc). It is based on the fact that each E. coli isolate produces a unique pattern (called a ribopattern) which can then compared to the pattern from a known source.

Two sources of known isolate patterns were used for this study for comparison purposes. One was the New Hampshire Regional Source Species database and the second was a local source species library that was developed by collecting scat samples from known animals in the vicinity of the Beach and then producing the ribopatterns for those animals. Since ribotyping involves a comparison analysis, a threshold similarity index is set in order to determine known isolates from unknown isolates. The use of the local source species ribopatterns for comparison turned out to be a very valuable asset in this study resulting in higher than average identification rate (Jones 2006). For this study the similarity index target was set at 90% similarity, however, 2 isolates that matched at 89% were included in the known isolates.

Jones (2006) monitored two of the same stations (BCHTWBTROLF and BCHTWBTROCR) that the NHDES Public Beach Inspection Program and TMDL Program had samples collected. A total of six samples were collected for ribotyping although the 9/21//05 sample was not used due to the *E. coli* concentration being too low to effectively identify isolate (see Table 5). All of the samples were collected during dry weather which was defined as days with less than 0.25 inches of rain in the previous 24 hours. Precipitation did occur in the previous 24 hours for the 8/30/05 sample but the amount was less than 0.25 inches.

Table 5: Fecal coliform/E.coli Concentrations (cts/100ml) for Ribotyping Samples

Site	7/5/05	7/21/05	8/3/05	8/18/05	8/30/05	9/21/05
BCHTWBTROLF		128	36		72	
BCHTWBTROCR	68			420		**28**

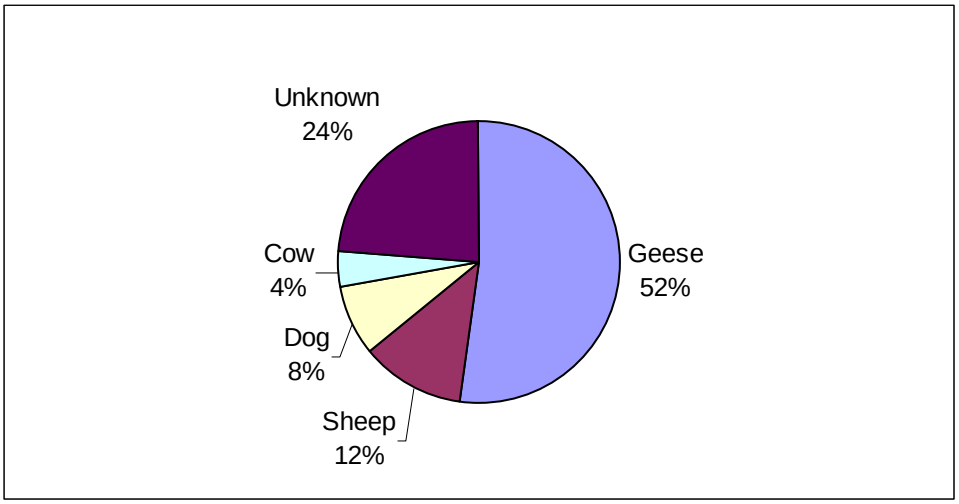
Bolded cell indcates sample was not used for ribotyping.

Likely sources of bacteria identified by the ribotyping analysis are shown in Table 6 and Figure 11. As shown, ribotyping identified source species for 76% (19/26) of the E.coli isolates in the water samples. The remaining isolates (24%) could not be matched with certainty to patterns in the ribopattern database. Bacteria from four different species were identified at Sand Dam Village Pond Town Beach swimming area. Of the identified isolates, geese constituted the largest portion (52%) followed by livestock [sheep (12%) and cows (4%) for a total of 16%] and dogs (8%).

Table 6: Species Identified by Ribotyping Beach Samples

Site	Sample Date	E.coli (cfu/100ml)	Total Isolates	Identified Isolates	Geese	Cow	Sheep	Dog
TROLF	7/21/05	40	5	1		1		
	8/3/05	36	5	5	3		2	
	8/30/05	72	5	5	4		1	
TROCR	7/5/05	68	5	3	2			1
	8/18/05	420	5	5	4			1
		TOTAL	**25**	**19**	**13**	**1**	**3**	**2**

Figure 11: Distribution of Isolates Identified by Ribotyping



Results of the ribotyping study indicate that the majority of the bacteria at Sand Dam Village Pond Town Beach is from geese. These findings are supported by visual observations by NHDES field staff of goose droppings as well as sightings of numerous geese in the area of the Beach. These findings are also supported by Table 7 which is a comparison of bacteria concentrations in scat (i.e, feces) from various sources. As shown, scat from geese is over 37 times more concentrated than the other sources tested. This implies that it would take less scat from geese to cause a violation of bacteria standards in surface waters as compared to other sources such as sheep, duck, horses, and goats.

Livestock (sheep and cows) were not observed in the vicinity of the Beach by field staff and are probably located further upstream in the watershed. It is also possible, however, that the source of bacteria from sheep and cows may be from their manure applied to agricultural fields or gardens located in the watershed. Although no dogs were

observed on the days samples were collected, it is believed that dogs do frequent the Beach on occasion. Dogs may also be present in the upstream watershed.

Table 7: Comparison of E. coli Concentration in Various Scat Samples (Jones, 2006)

Sample	Species	Date	Location	E.coli Concentration (cfu/g wet wt.)
GE1	Geese	7/21/05	Troy	>222,000,000
GE2	Geese	7/21/05	Troy	>222,000,000
GE3	Geese	7/21/05	Nottingham	>222,000,000
ST1	Septage	9/6/05	Nottingham	789
SP1	Sheep	10/3/05	Troy	5,888,889
HO1	Horse	10/3/05	Troy	2,222,222
HO2	Horse	10/3/05	Troy	1,556
DA1	Cow	10/3/05	Troy	122,222
DU1	Duck	10/3/05	Troy	4,444
GO1	Goat	10/3/05	Troy	488,889

4 SOURCES OF BACTERIA

4.1 Existing Point Sources of Bacteria

Point source discharges include discernible, confined, and discrete conveyances such as the discharge from the effluent pipes of wastewater treatment plants or permitted combined sewer overflows (i.e., pipes that convey a mixture of stormwater and sewage during wet weather events). In addition, discrete stormwater discharges from municipal separate storm sewer systems (MS4) covered by the EPA National Pollutant Discharge Elimination System (NPDES) Phase II stormwater program regulations are considered point sources for this TMDL. All point source discharges must have a federal National Pollutant Discharge Elimination System (NPDES) discharge permit.

There are no wastewater treatment plant discharges or combined sewer overflows (CSOs) in the Sand Dam Village Pond watershed (the Troy Wastewater Treatment Facility (WWTF) discharges approximately two miles downstream of the pond into the South Branch Ashuelot River). In addition, the town of Troy is not covered by the EPA Phase II NPDES stormwater program regulations for small municipal separate storm sewer systems (MS4). Consequently, it is concluded that there are no known existing point sources in the study area.

4.2 Existing Non-Point Sources of Bacteria

In general, non-point sources ("NPSs") of pollutants include all pollutant sources other than point sources. Compared to point sources, NPSs of pollution are diffuse and more difficult to quantify. Examples of NPSs are provided below.

- *Stormwater runoff not conveyed through MS4 systems*. Sources of bacteria in stormwater can include fecal matter deposited on the land by wildlife and domesticated animals (including pets and farm animals). During wet weather events, rainwater running over the land may come in contact with the fecal matter and convey it to the surface water. If stormwater runoff is a major source, elevated concentrations in the surface water will usually occur during or shortly after wet weather events.
- *Illicit connections of sewer pipes to storm drain systems.* In some communities, sewer pipes from residents or businesses have been found to be connected to storm drain pipes instead of sewer pipes. Consequently, instead of transporting the raw sewage to a facility where it can receive proper treatment (such as a wastewater treatment facility), the raw sewage is instead transported by the storm drain to the surface water. Such connections are illegal and can cause elevated bacteria concentrations in a surface water during wet and dry weather.
- *Failed septic systems.* Effluent from failed septic systems adjacent to or upstream of the surface water of interest can cause elevated ambient bacteria concentrations during wet and dry weather.

- *Direct deposition of fecal matter*. Deposition of fecal matter by animals, waterfowl and humans (i.e. babies with dirty diapers playing in the water) directly into or upstream of the surface water of interest can cause elevated bacteria concentrations during wet or dry weather.

It's possible that all of the above NPSs could be contributing to bacteria levels recorded at the Beach. However, based on field reconnaissance and the results presented in the previous chapter, a best estimate of which bacteria sources are most important relative to the amount of bacteria they likely contribute is presented in Table 8. A simple ranking system of "High", "Medium" or "Low" was used to indicate the relative amount of bacteria the source is estimated to contribute. Major sources of bacteria were assigned a "High" rank. Bacteria sources that are believed to contribute little if any bacteria were assigned a "Low" rank and sources that contribute moderate amounts of bacteria were given a "Medium" rank. Such information is useful for guiding restoration efforts.

As shown in Table 8, bacteria from stormwater runoff and direct deposits of fecal matter at the Beach and Pond received the highest ranking as they are believed to be the major sources of bacteria to the Beach. Illicit connections and failed septic systems are not believed to be major sources of bacteria and were therefore given a low ranking. Direct deposition of bacteria from people recreating at the Beach (i.e. swimming) was also give a low ranking as no people were observed swimming at the beach on the days that samples were taken for this study.

Table 8: Ranking of Potential Sources of Bacteria

Bacteria Source	Ranking	Comments
Non-human Direct Deposition to Surface Waters and Stormwater runoff (Non-MS4) and	High	As discussed in section 3.2 and 3.3, bacteria violations frequently occur during dry and wet weather. Consequently, direct deposition of fecal matter to surface waters (which can occur in dry or wet weather) and bacteria associated with stormwater runoff were assigned a high priority. Deposition of goose droppings in the water and on the land immediately adjacent to the Beach h is believed to be the major source of bacteria to the Beach swimming area. This is supported by the following: • Visual observations of geese and goose droppings at the Beach on several occasions • Ribotyping analyses which showed the majority of bacteria is from geese (52% - see section 3.4); • Multiple violations of the bacteria criterion during dry and wet weather. It's possible that other animals, such as dogs, may also be responsible for fecal matter in the water or on the land immediately adjacent to the Beach although none were observed on the days when sampling was conducted for this study. Approximately 8% of the isolates analyzed for the ribotyping study were from dogs (see section 3.3). Livestock (sheep and cows) contribute 16% of the bacteria (see section 3.3). These animals may be located upstream of the Beach or their bacteria could be from their manure applied to agricultural fields or gardens in the upstream watershed. When it rains, bacteria from the manure can be transported to surface waters by stormwater runoff. Further investigation is needed to identify the source of livestock bacteria.
Illicit Connections And Failed Septic Systems	Low	Although it's possible that illicit connections and failed septic systems could exist in the upstream watershed these sources were assigned a rank of "Low" since none were observed in the immediate vicinity of the Beach. In addition, the ribotyping results did not indicate any human sources of bacteria although its possible some may exist as 24% of the samples could not be identified. Further investigation in the watershed is needed to confirm the conclusion that these sources are not major contributors of bacteria to the Beach.
Direct Deposition by People Swimming	Low	People recreating in surface waters (i.e., babies with dirty diapers playing in the water or swimmers that haven't bathed properly) can also result in elevated bacteria levels. During this study no people were observed swimming at the Beach, consequently this source was assigned a Low ranking.

5 TMDL AND ALLOCATIONS

5.1 Definition of a TMDL

According to the 40 CFR Part 130.2, the TMDL for a waterbody is equal to the sum of the individual loads from point sources (i.e., waste load allocations or "WLAs"), and load allocations ("LAs") from nonpoint sources (including natural background conditions). Section 303(d) of the CWA also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety ("MOS") which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

In equation form, a TMDL may be expressed as follows:

$$TMDL = WLA + LA + MOS$$

where:

WLA = Waste Load Allocation (i.e. loadings from point sources)

LA = Load Allocation (i.e., loadings from nonpoint sources including natural background)

MOS = Margin of Safety

TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure [40 CFR, Part 130.2 (i)]. The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they are sufficient to account for the MOS.

5.2 TMDL Allocation and Percent Reduction

As mentioned in section 5.1, TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure. To satisfy recent legal challenges on how TMDLs should be expressed, a TMDL in terms of the maximum allowable load per day, (i.e., billions of E. coli per day) is provided in Appendix C. As shown in Appendix C, the TMDL is a function of flow through the Beach swimming area. Although it is possible to express a TMDL in terms of a load per day, NHDES believes that the best way to express this TMDL is in terms of concentration (counts / 100 mL); reasons for this are provided below:

- The units are consistent with how bacteria water quality criteria are expressed;
- The units are consistent with how compliance with ambient bacteria water quality criteria will be determined;
- It is simpler and easier for the public to understand;
- Progress towards compliance is easier to measure and track than a TMDL expressed in E. coli /day which requires an estimate of flow as well as concentration; and
- Like the bacteria water quality criteria, a TMDL expressed in terms of concentration would be applicable during all times of the year.

Since concentrations are not directly additive, the TMDL equation presented in section 5.1 requires some adjustment to accommodate a TMDL expressed in terms of concentration. The revised equation is presented below.

TMDL = E. coli Water Quality Criterion $\geq$ WLA ($_{p1}$) $\geq$ LA ($_{n1}$) $\geq$ WLA ($_{p2}$) $\geq$ etc.

Where:

$\geq$ means greater than or equal to
WLA ($_{p1}$) = allowable concentration for point source category 1
LA ($_{n1}$) = allowable concentration from nonpoint source category 1
WLA ($_{p2}$) = allowable concentration from point source category 2 etc.

What this equation says is that if the receiving water is comprised of point and nonpoint sources, and if all point and nonpoint sources have bacteria concentrations that are less than or equal to the bacteria water quality criterion, then the concentration of bacteria in the receiving water will be less than or equal to the bacteria water quality criterion.

This equation implies a goal of meeting bacteria standards at the point of discharge (ie., "end-of-pipe) for all sources. Although this may be the goal, it is not the intent of this TMDL to set permit limits for any point or nonpoint source discharge unless otherwise required by state law or regulation (see section 2.2). This is especially true for stormwater discharges covered by the EPA NPDES General Stormwater Permit program. The NPDES stormwater permits are Best Management Practises ("BMPs") based permits which require communities to develop and implement comprehensive stormwater management programs that include BMPs. New Hampshire and EPA believe that BMP based permits that are part of a comprehensive stormwater management program, with specific emphasis given to pollutants causing or contributing to water quality problems, can be consistent with the WLAs established for stormwater discharges in TMDLs. Consequently, although end of pipe bacteria measurements can identify and help prioritize sources that require attention, compliance with this TMDL will be based on ambient water quality and not at the point of discharge (i.e., end-of-pipe).

As discussed in section 2.2 and 2.3, there are two bacteria water quality criterion applicable to this study; a single sample criterion equal to 88 *E. c*oli per 100 mL and a

geometric mean equal to 47 *E. coli* per 100 mL. Since there are two criteria, two TMDLs are presented. The TMDL based on the single sample criterion is presented in Table 9 and the TMDL based on the geometric mean criterion is presented in Table 10. As previously discussed, the TMDL in both tables was set equal to the criterion and the point (WLA) and nonpoint (LA) sources were set equal to a value less than or equal to the bacteria water quality criterion. For reasons discussed in section 5.3 below, the explicit MOS was set to zero.

Table 9: Single Sample TMDL Based on Concentration

Bacteria Source	WLA	LA	Explicit MOS	TMDL
	(counts *E. coli* / 100 ml)			
WWTF	0			
CSO	0			
Stormwater (MS4)	88			
Stormwater (Non-MS4)		88		
Non-Human Direct Discharges to Surface Waters		88		
Illicit Sewer Connections		0		
Failed Septic Systems		0		
People Recreating in the Water (i.e., Swimming)		88		
	88	**88**	**0**	**88**

Table 10: Geomean TMDL Based on Concentration

Bacteria Source	WLA	LA	Explicit MOS	TMDL
	(counts *E. coli* / 100 ml)			
WWTF	0			
CSO	0			
Stormwater (MS4)	47			
Stormwater (Non-MS4)		47		
Non-Human Direct Discharges to Surface Waters		47		
Illicit Sewer Connections		0		
Failed Septic Systems		0		
People Recreating in the Water (i.e., Swimming)		47		
	47	**47**	**0**	**47**

Sources were allocated a concentration of 0 counts/ 100 ml if

- there was no evidence that that the source currently exists and there is little likelihood that such a source will exist in the future, or
- the source exists but is illegal.

As discussed in section 4.1, there are no WWTFs or CSOs in the watershed and none are expected in the future; consequently, allocations for these point sources were set equal to zero. Although none of the communities in the watershed are currently covered by the EPA NPDES MS4 General Stormwater Permit program, an allocation was included for MS4 Stormwater in event the EPA stormwater permit program is expanded in the future to include communities such as Troy. Because there are no known illicit sewer connections to storm drains or failed septic systems (see section 4.1), and since illicit sewer connections and failed septic systems which violate bacteria standards are illegal, allocations for these nonpoint sources were set equal to zero. All other source

categories were assigned an allocation equal to the bacteria water quality criterion. These include non-MS4 stormwater and non-human direct discharges to surface waters (such as waterfowl or livestock defecating directly in the surface water). In addition a nonpoint source allocation for people recreating in the surface waters was also included to account for the fact that people swimming at the Beach can also cause bacteria levels to rise. Examples include babies with dirty diapers playing in the water, or swimmers who have not bathed properly.

An approximation of the percent reduction needed to achieve each of the TMDLs is provided in Table 11. The upper detection limit of single samples was 400 cts/100 mL. On numerous occasions measurements exceeded this upper detection limit and were reported as ">400 cts/100mL." To determine the load reduction for the single sample TMDL a value 50% above the upper detection limit (i.e., 600 cts/100 mL) was used. Load reductions for the geometric mean TMDL were calculated based on the highest calculated geometric mean of 219 cts/100mL. As shown, bacteria concentrations must be reduced by approximately 85% to achieve the single sample TMDL and approximately 79% to achieve the TMDL based on the geometric mean criterion. These represent significant reductions which will be challenging to achieve.

Table 11: Percent Reduction in Bacteria Needed to Achieve TMDL

	Single Sample	Geomean
Maximum Measured Concentration (E. coli /100 ml)	600	219
TMDL (E. coli / 100 ml)	88	47
% Reduction Needed to Meet TMDL	85%	79%

5.3 Margin of Safety (MOS)

Setting an explicit margin of safety for this TMDL was not considered necessary because there is a sufficient margin of safety implicit in the methodology used to establish the TMDL. For example, setting all sources less than or equal to the bacteria criterion is conservative because it does not account for mixing or dilution in the receiving water. In addition the methodology assumes no losses of bacteria due to settling or die-off, which are known to take place in surface waters.

5.4 Seasonal Considerations

As discussed in section 5.2, the bacteria water quality criterion are applicable at all times. Since the TMDLs are set equal to the bacteria criterion, they too are applicable at all times and are therefore protective of water quality under all conditions and seasons.

6 IMPLEMENTATION PLAN

6.1 Recommendations to Reduce Bacteria and Restore Swimming at the Beach

As discussed in the previous sections, bacteria levels at the Sand Dam Village Pond Town Beach swimming area must be reduced by approximately 79% based on geometric mean concentrations and approximately 85% based on single sample values. Further, stormwater runoff and direct discharges of non-human fecal matter to the Beach swimming area or tributary surface waters are believed to be the primary sources of bacteria to the Beach. Finally, results of the ribotyping study indicate that geese are responsible for the majority of bacteria at the Beach (52%) followed by livestock (16% - sheep and cow), and dogs (8%). The source of approximately 24% of the bacteria samples could not be identified.

Based on the above, the following activities are recommended to try to reduce bacteria to levels acceptable for swimming at the Sand Dam Village Pond Town Beach. Other measures may be necessary to completely restore the Beach. Reducing bacteria levels by over 79% will take a concerted effort by the Town and others to accomplish and should be implemented in phases with each phase followed by monitoring of the surface water to determine when bacteria levels are acceptable for swimming.

Post Warning Sign and Close Beach When it Rains:

As discussed in section 3.2, the Beach frequently exceeds the geometric mean bacteria criterion which is a good indicator that bacteria levels will usually be high on any given day. Consequently, to protect potential swimmers it is recommended that the Town post the Beach with a sign warning them that the beach frequently has high bacteria levels and that they are swimming at their own risk. NHDES can assist with the Town with wording for the signs.

In addition, and as shown in Figure 9 and Figure 10, the bacteria criterion is almost always exceeded when rainfall exceeds approximately 0.25 inches. Consequently, it is recommended that the Town install a rain gauge and post signs closing the beach when rainfall exceeds 0.25 inches in any 24 hour period. Prior to reopening the Beach, it is recommended that the Town either sample the Beach to determine if bacteria standards are met, or wait a minimum of 3 consecutive days when rainfall is less than 0.25 inches. As measures are implemented to reduce bacteria levels, the rainfall threshold for closing the beach should rise resulting in fewer Beach closures. To determine new rainfall thresholds in the future, the Town will need to collect more bacteria samples and measure rainfall amounts on the days samples are collected.

Waterfowl Management:

Numerous geese and goose droppings have been observed in the water and on the land in the vicinity of the Beach (such as in the sand, nearby grassed areas and the ball field). Geese are believed to be the major source of bacteria to the Beach and should be given top priority for clean up. If the geese are not properly managed, it is doubtful that the Beach will be able to attain bacteria standards and be open for swimming on a consistent basis.

Goose droppings should be collected and disposed of away from the Beach and in a manner that will prevent stormwater from coming in contact with them and transporting their bacteria to surface waters. The current method of raking the droppings to the corner of the beach and leaving them there does not appear to be effective. The Town should also investigate and implement methods to discourage geese (and other waterfowl) from frequenting the Beach, pond and surrounding area. Methods for managing geese may be found on the World Wide Web.

Livestock Management:

Field reconnaissance conducted for this study did not identify any livestock in the immediate vicinity or just upstream of the Beach although it's possible some could exist further upstream. It is recommended that the Town conduct investigations to determine the source of livestock (sheep and cow) bacteria. If livestock are found it is recommended that they be prevented from directly accessing surface waters tributary to Sand Dam Village Pond. In addition, manure deposited on the land should be properly managed to minimize contact with stormwater runoff and transport to the pond. Where feasible, vegetated buffers should be provided to help filter runoff and reduce bacteria loads before entering surface waters.

Pet Management:

As previously mentioned bacteria from dog waste constituted approximately 8% of the bacteria samples collected for the ribotyping analysis. For this reason and the fact that pet waste is a relatively simple source to reduce or eliminate, it is recommended that the Town take steps to encourage people to clean up their dog's waste and to dispose of it properly. There are a variety of products available for parks and beaches that dispense plastic bags to dog owners and provide a container for proper disposal of the waste. To help ensure compliance, the Town may want to adopt a "pooper scooper" ordinance and make it mandatory for people to clean up after their pets.

Additional Investigations to Identify Human Sources of Bacteria:

Results of the ribotyping analysis did not indicate the presence of human wastewater or human septage although it is possible some could exist as 24% of the bacteria isolates could not be identified. Preliminary investigations in the immediate vicinity of the beach did not reveal any obvious sources of wastewater or septage such as

illicit connections of sewer pipes to storm drains or failed septic systems. Once the sources of bacteria from waterfowl, livestock and dogs have been addressed, and if the Beach is still violating bacteria standards, it is recommended that the Town conduct an illicit connection study in the watershed to determine if these sources actually exist and their location. If illicit connections are found they should be eliminated and if failed septic systems are found they should be fixed. NHDES has staff experienced with detecting illicit connections and can provide technical assistance if requested.

6.2 Monitoring

Pending resources, the NHDES Public Beach Inspection Program plans to continue monitoring of the Sand Dam Village Pond Town Beach in the future. As in the past, NHDES expects to sample the Beach at least twice each summer.

Although NHDES plans to monitor the Beach, local volunteers are encouraged to assist with sampling to obtain data on a more frequent basis. Prior to collecting samples, volunteers should review their sampling protocols with NHDES to ensure the data will be of high quality and useable for assessment decisions. If volunteers are interested in collecting samples, the Town of Troy should be approached to see if they would be willing to pay for laboratory analyses of the E. coli samples or even analyze the samples at the Troy WWTF. In addition, NHDES will work with the volunteers to input their data into the NHDES Environmental Monitoring Databases (EMD). The majority of surface water monitoring data collected by NHDES is in the EMD and all data in the EMD is readily accessible to the public.

7 PUBLIC PARTICIPATION

7.1 Description of Public Participation Process

EPA regulations [40 CFR 130.7 (c) (ii)] require that calculations to establish TMDLs be subject to public review. The following is a description of the public participation process for this TMDL:

(This section will be written after completion of the public participation process.)

7.2 DES Response to Comments

(This section will be written after completion of the public participation process.)

8 REFERENCES

Jones, 2006. Freshwater Beach Total Maximum Daily Load Microbial Source Tracking Study. Dr. Stephen H. Jones. Jackson Estuarine Laboratory Center for Marine Biology, Department of Natural Resources, University of New Hampshire. February 2006.

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9 APPENDICES